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Small Grain Rusts and the Progress of Barberry Eradication in Iowa

Treating a common barberry bush with salt. To kill a barberry bush 12 inches in diameter at the base, use 10 to 15 pounds of crushed rock salt. It must be piled in and about the base of the bush so as to surround every shoot. Care must be taken not to miss any shoots growing a few feet from the main bush.

IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

EXTENSION SERVICE
AGRICULTURE AND HOME ECONOMICS
R. K. Bliss, Director

AMES, IOWA

Cooperative Extension Work in Agriculture and Home Economics, Iowa State College of Agriculture and Mechanic Arts and the United States Department of Agriculture Cooperating.

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Small Grain Rusts and the Progress of Barberry Eradication in Iowa

By I. E. Melhus and M. A. Smith[1]

The small grain crops of Iowa, as a group, are attacked annually by five different rusts, which frequently are considered identical by many growers. Altho these rusts may resemble one another in outward appearance, they differ markedly in certain characters, host relationships and relative economic importance. One of these rusts occurs chiefly on the stems of oats, wheat, rye and barley, and certain wild grasses and is known as stem rust, while the other four are leaf rusts.

The damage occasioned by cereal rusts is well known and the development of rust is anxiously watched by farmers and business men when grain is maturing. In 1916, stem rust alone reduced the grain crop of the middle west over 200,000,000 bushels. The total loss due to stem rust in Iowa on wheat, oats, barley and rye during the years 1916 to 1926, inclusive, was estimated at 38,613,000 bushels of grain.

The leaf rusts, tho not as destructive as stem rust, are of much importance, for they destroy the leaves and thereby deprive the infected plants of the food supply necessary to their proper development. Grain produced by such plants may be materially reduced in quantity and of poor quality.

Rusts are caused by microscopic parasitic plants closely related to such organisms as bread mold and green mold of decaying fruit. Some of the grain rusts are peculiar in that they must live on two different plants to complete their life cycles. Stem rust is one of these. In the spring it spreads from grain to common barberry and then back to grain the same season. If we can eliminate the common barberry from the middle west, serious outbreaks of stem rust will not occur. Obviously, therefore, it is of great importance to know the relations of the barberry and black stem rust, the history and distribution of the common barberry in Iowa, and methods used in its eradication.

Black Stem Rust

Black stem rust *(Puccinia graminis)* is a fungous disease peculiar to wheat, oats, barley and rye and a number of wild grasses. It lives part of its life on grain and part on the common barberry, from which it again spreads to grain. This has been known for more than 50 years, but only within the last decade have we come to appreciate fully the important part played by this shrub as a host and spreader of stem rust.

In order to live thruout the year and from year to year in the northern and central parts of the United States, the stem rust fungus must spend a part of its life cycle on its alternate host, the common barberry, and the remainder on the small grains or susceptible wild grasses. The most obvious way to check the spread of stem rust, therefore, is by the eradication of the common barberry.

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The barberry eradication campaign in Iowa is conducted jointly by the Extension Division of the Iowa State College of Agriculture and Mechanic Arts and the Office of Cereal Crops and Diseases of the Bureau of Plant Industry of the United States Department of Agriculture.

HOW STEM RUST LIVES

Black stem rust appears in the fall and spring on stubble and straw as long black blister-like spots filled with winter spores or "seeds" of the fungus (fig. 1, e). These start to grow or germinate in the spring and produce another crop of spores (fig. 1, d), which are blown by the wind to the leaves of the barberry. Under favorable conditions these secondary spores germinate and penetrate the leaves of the barberry (fig. 2), causing bright yellow spots. On these yellow spots on the barberry leaves another crop of spores (fig. 1, g) is produced, which are very light and easily blown about, some finding their way to grain fields. Alighting on the leaves and stems of the grain, they germinate and send their threads into the tissues and in about a week grow into brick red blisters. In each of these blisters are thousands of other spores, the red rust spores (fig. 1, c), each one of which may blow to neighboring grain plants and in turn germinate and produce additional stem rust. Once it gets into a grain field it will spread rapidly, under favorable conditions.

The rust usually has obtained a good foothold in the fields by the time the grain comes into blossom. At this time the foliage is dense, dew and rain evaporate slowly, and if the temperature is moderately high, the conditions for germination and growth of rust are nearly ideal. It usually is between the time of heading and ripening of the grain that stem rust becomes abundant and does serious damage.

The winter spores of stem rust found on stubble and straw are incapable of producing rust on other grain except thru the aid of the common barberry. The relation of this bush to stem rust, therefore, is a vital one.

Barberry Eradication in Iowa

A preliminary barberry survey was made in Iowa in 1917 by the Experiment Station. In this limited survey over 20,000 bushes were located in the cities and towns and about farmsteads. The barberry eradication campaign in Iowa was begun by the U. S. Department of Agriculture in April, 1918, in cooperation with the state college of agriculture. A state-wide campaign of education was initiated at that time. Thru the appeal made by the U. S. Department of Agriculture and the state during 1918, over 400,000 common barberries were voluntarily destroyed by the owners in order to protect the grain crop from stem rust. The same year a barberry eradication campaign was begun by the U. S. Department of Agriculture in cooperation with the colleges of agriculture, the state departments of agriculture and other agencies in 12 other north-central grain growing states, namely Colorado, Illinois, Indiana, Michigan, Minnesota, Montana, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin and Wyoming. The barberry eradication law, making it a legal offense to grow the common barberry, was passed by the legislature in February, 1919.

Prior to the barberry eradication campaign, many of the nurseries in the state carried extensive plantings of both the green and purple varieties of the common barberry. With the enactment of the state law, making it illegal to grow or sell the barberry, the nurseries removed and destroyed all their common barberries and no longer list them for sale.

In 1919, the first survey of the cities and towns was completed. In addition, a farm-to-farm survey was carried on in Story County, the results of which showed the necessity of a systematic rural survey for barberries over the entire state. This survey was continued and

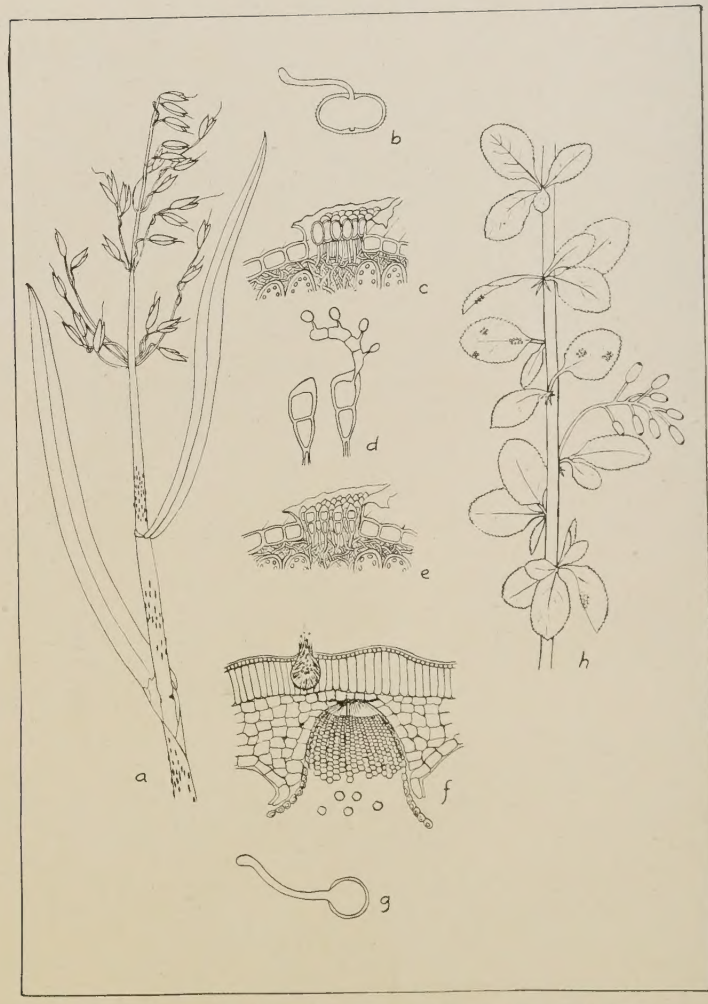

Fig. 1. a. Red rust stage of stem rust on leaf sheath of oat plant.
b. Red or summer spore germinating.
c. Cross section of leaf sheath showing how summer spores are borne.
d. Winter spores; one germinating.
e. Cross section of leaf sheath showing how winter spores are borne.
f. Cross section of barberry leaf showing spores in cluster-cup.
g. Germinating cluster-cup spore.
h. Common barberry showing rust spots on leaves.

September, 1924, marked the completion of the original farm-to-farm survey in Iowa.

During the course of the original survey it was noted that barberry seeds might lie dormant in the soil several years before germination occurred and seedlings appeared. Moreover, many bushes in inaccessible and out-of-the-way places were cut off or improperly dug by property owners or tenants and no record was made of their existence. It has been necessary, therefore, to conduct a second survey to locate bushes and seedlings missed in the original survey. On December 31, 1926, this second survey had been completed in 21 counties in the state and over 110,000 barberry bushes and seedlings had been found and destroyed.

In the first few years of the campaign it became apparent that properties on which barberries were found needed one or more reinspections. These reinspections are necessary in order to destroy any sprouts or seedlings appearing, thus preventing their becoming infected and starting new stem rust epidemics. As a rule, such a resurvey has followed the first or original survey in about two years. Whenever practicable, resurvey has been combined with the second survey.

Spread of Stem Rust from Barberry to Grain

Common barberry bushes have been found in every county in Iowa. At any time from April to August, rust infection may appear on the barberry leaves. In some years the amount of infection is slight. In other years, nearly every leaf of a bush may be infected. Favorable weather conditions play a very important part in the abundance and severity of infection. The greatest amount of infection has been found on plantings in the country and in the smaller towns, altho infected barberry is common enough in the larger cities.

During the past twelve years, the first germinating stem-rust spores on stubble and wild grasses were found between April 3 and May 3. The first rust on barberry leaves appeared from April 23 to May 15 in different years and on grain between May 21 and June 24. The dates of the first infections observed on barberries and on grains in the years 1916 to 1927, inclusive, are given in table I.

Each year evidence shows that stem rust on grains and grasses appeared shortly after its appearance on the barberry. The rust may start on the barberry early enough to permit rust spores from the barberry to germinate and produce an outbreak of rust on the grain.

TABLE I. DATES OF THE FIRST APPEARANCE OF STEM RUST ON BARBERRIES AND ON GRAINS IN IOWA IN THE YEARS 1916 TO 1927, INCLUSIVE.

Year	Rust first observed on	
	Barberries	Grain
1916	May 7	May 21
1917	May 5	June 15
1918	May 8	May 25
1919	April 29	May 28
1920	May 15	June 11
1921	May 3	June 9
1922	May 8	June 23
1923	May 3	June 24
1924	April 26	June 8
1925	April 23	June 8
1926	May 5	June 7
1927	April 28	June 3

Many cases have been found, during the past eleven years, which show clearly that rusted barberry bushes start local outbreaks of stem rust on grains and grasses in their immediate vicinity. Near Garner, Hancock County, over 1,000 barberry bushes were found in a five-acre woodlot in July, 1922. The bushes were severely rusted. A field of barley bordering the woodlot was so badly rusted that the yield of grain was reduced 75 percent. The owners stated that they had always experienced difficulty in growing small grain in the vicinity of this woodlot (fig. 3).

About 30 common barberry bushes, heavily rusted, were found in June, 1924, on an old abandoned farmstead near Redding, Ringgold County. By July 4 the oats growing close to the barberries were severely rusted. Ten days later the entire oat field was heavily rusted. The rust unquestionably had spread from the barberries to the oats.

On July 18, 1926, a very clear case of the spread of stem rust from barberry to grain was noted on a farm near Clermont, in Fayette County. A heavily rusted barberry bush was found near a fence adjoining an oat field (fig. 4). When first noted the oats near the barberry were found to be heavily rusted. On July 25, heavy infection was found thruout the entire field, and a week later it had spread to many nearby oat fields.

During the survey of Woodbury County, in July, 1926, field agents located five heavily rusted barberry bushes. Rust was observed to be

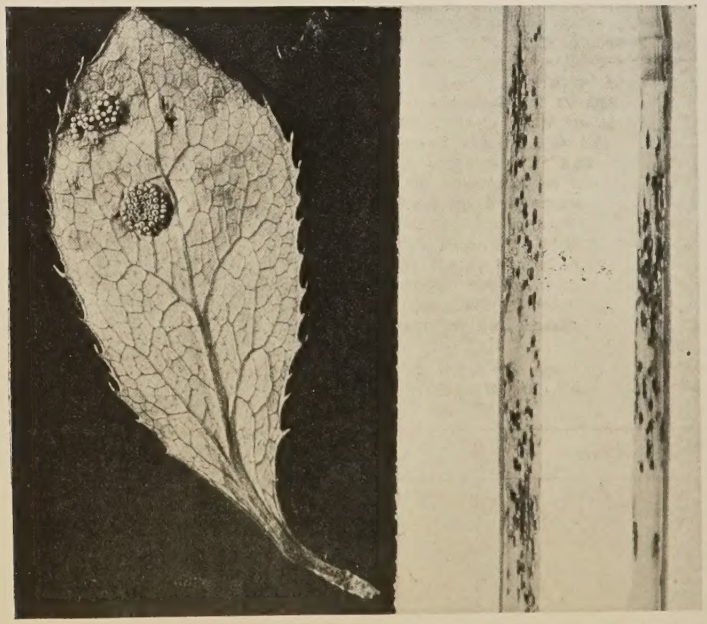

Fig. 2. (Left) Barberry leaf infected with black stem rust. This is the cluster-cup stage of stem rust. (Right) Stems of oats infected with black stem rust.

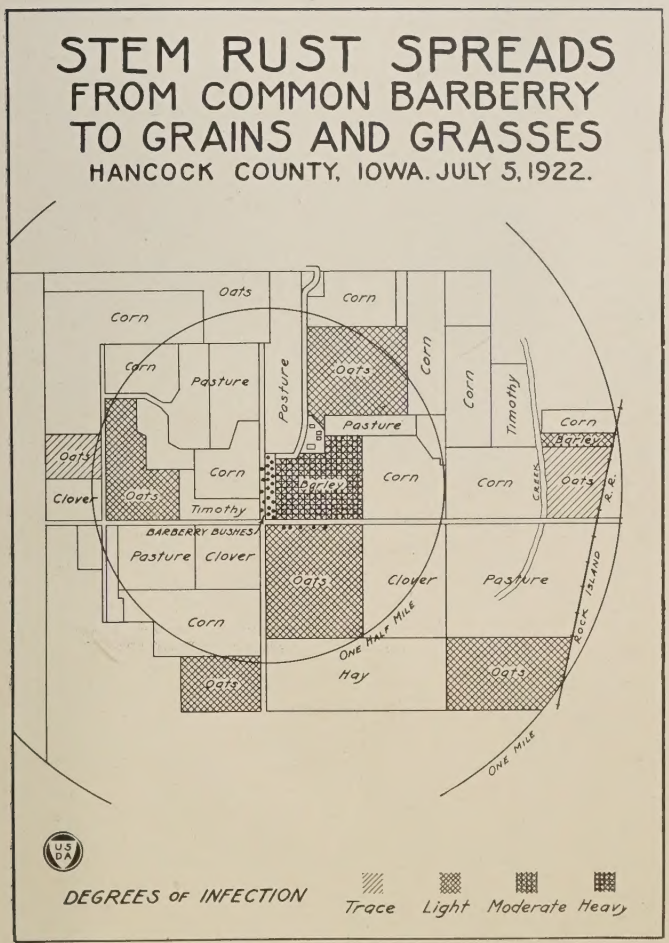

Fig. 3. Spread of rust from common barberries to barley near Garner, Hancock County, Iowa, in 1922. When the 38 acre field next to the barberry planting was threshed it yielded less than 10 bushels per acre. The density of the shading indicates the amount of stem rust in surrounding fields.

spreading to oats in fields adjacent to the barberry bushes. Eight days later, the oats near the barberries were heavily rusted and the infection had spread to farther oat fields. The barberries undoubtedly were responsible for the spread of rust.

Fig. 4. Large common barberry growing next to oat field. Stem rust was very heavy on the oats in adjacent fields. The accompanying colored plate shows detail of twig taken from this bush.

How to Identify the Common Barberry

The common barberry *(Berberis vulgaris* L.*)* is an ornamental shrub, which was introduced into North America from Europe. It had become well established in New England by the end of the seventeenth century. Later, it was carried westward by settlers. The earliest reliable information regarding the introduction of the barberry in Iowa dates back to 1851. Thousands of bushes were planted in the state from this date until 1918, when the barberry eradication campaign was begun.

The common barberry is an erect, spiny shrub, usually five to eight feet high, but in Iowa it often grows to a height of 12 or 15 feet. The slightly ridged stalks are woody and covered with dull gray bark. Branched, usually triple-pointed, spines develop along the stems. Just above these spines occur the clusters of closely bristle-toothed leaves. The yellow flowers and red berries occur in drooping, currant-like clusters. The conspicuous red berries are numerous and usually remain on the plants thruout the winter (see colored plate).

The Japanese barberry *(Berberis thunbergii* D C.*)* is grown extensively for ornamental purposes in Iowa and is not susceptible to stem rust. Its planting in place of the common barberry is being encouraged. The Japanese barberry is a low, gracefully spreading shrub, seldom more than four or five feet tall (fig. 5). The bark is reddish brown and the spines, usually single pointed, are smaller than those

TWIG FROM A COMMON BARBERRY BUSH (Actual Size)

Learn to know the common barberry by observing closely (1) the clustered leaves, either green or purple, with saw-tooth edges, (2) the thorns, usually three in number, below the leaf clusters, (3) the bunches of bright red, oval berries, (4) the grey, outer bark, and the bright yellow, inner bark.

The common barberry is a tall, erect shrub, usually four to eight feet in height. Originally it was introduced for ornamental purposes, but rapidly became naturalized and spread as birds scattered the seeds. Look for common barberry bushes wherever any bushes grow.

Reprint from Illinois Agricultural Experiment Circular 308, furnished by the Conference for the Prevention of Grain Rust.

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of the common barberry. The red berries are borne singly, or in small groups of two to four, like gooseberries. The edges of the leaves are usually smooth.

The Common Barberry Has Escaped from Cultivation

As stated earlier, the common barberry was introduced into Iowa as an ornamental shrub. These early plantings have been responsible for most of the escaped or wild bushes found in the state. Bushes have escaped from cultivation by means of seeds scattered by birds, animals and water for several miles from the fruiting bushes. As a result, bushes may be found in woodlands and brushy pastures, along stream banks, on rocky cliffs and in woodlots, orchards and fence rows. Over 65,000 escaped bushes have been found on 856 properties in Iowa (fig. 6).

An excellent example of the spread of barberries was seen in Fayette County. In the summer of 1926 field men found and destroyed over 10,000 escaped bushes and 15,000 seedlings scattered over an area of twelve square miles (fig. 7). In 1922, hundreds of escaped bushes and seedlings were found along the rocky, timbered hills overlooking the Mississippi River near McGregor. In Jones County, 390 bushes were found along streams and in dense timber over an area of 25 square miles. Along the banks of the Wapsipinicon River in Clinton County, a large hedge of sprouting barberries was discovered. This hedge had been cut off by the owners in 1918. In 1923, field agents located over

Fig. 5. The Japanese barberry is a low, gracefully spreading shrub. The bark is reddish in color. The spines are usually single. The red berries are borne singly or in small clusters of two or three. It does not spread stem rust.

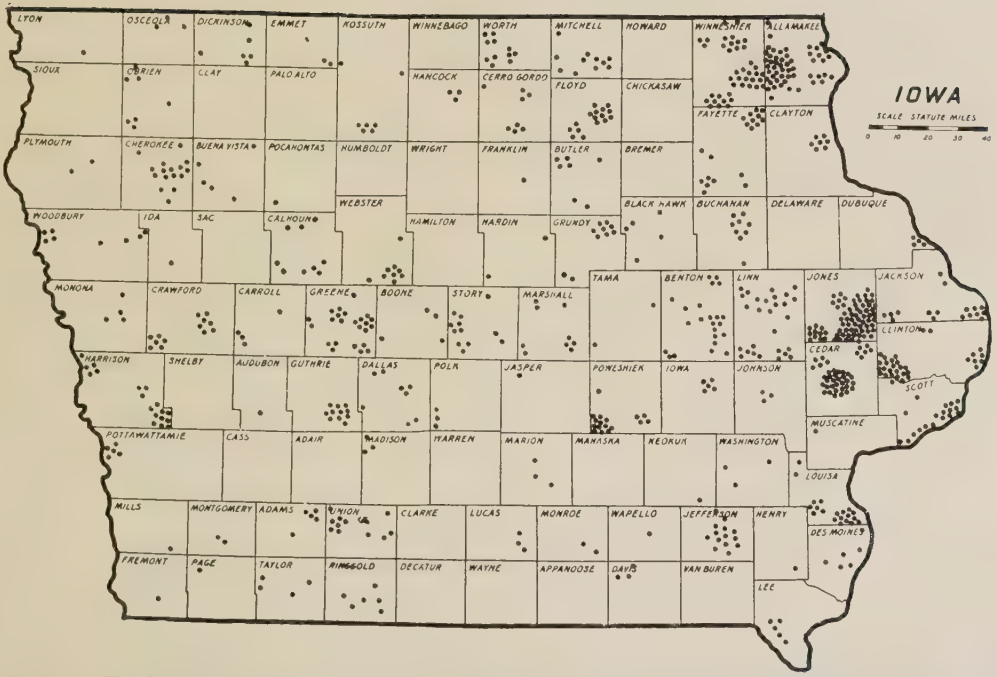

Fig. 6. Each single dot on this map of Iowa represents a property on which escaped barberries have been found. Escaped barberry bushes numbering 65,976 have been found on 856 properties in Iowa since 1918.

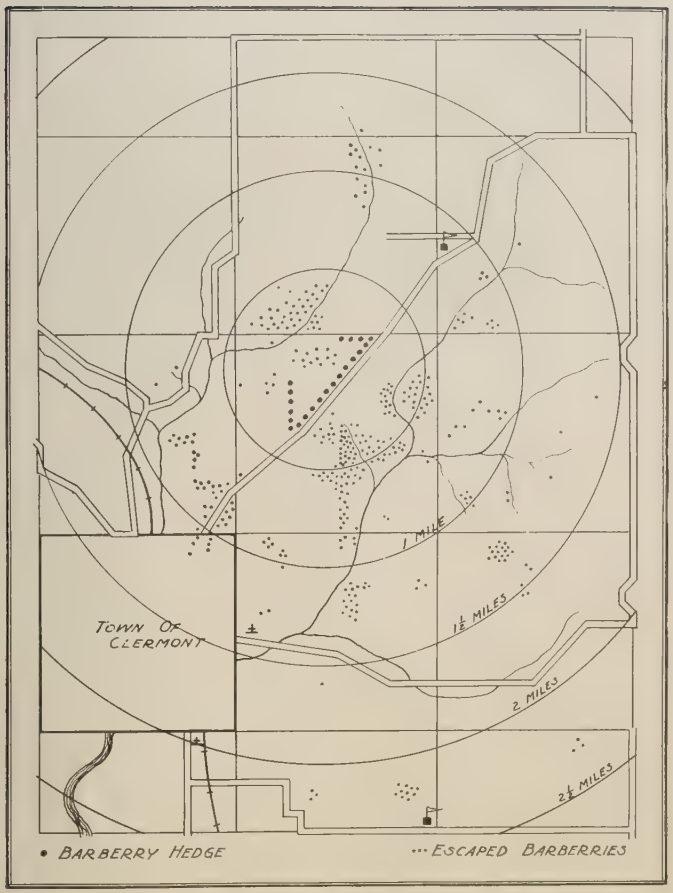

Fig. 7. This map shows how common barberries have spread from a hedge in Fayette County, Iowa, to eleven sections. Birds were largely responsible for the spread of seeds.

4,000 escaped bushes and many seedlings widely scattered from this hedge. In the summer of 1926, in O'Brien County, 600 bushes and 100,000 seedlings were found and destroyed in a cut-over woodlot. Many bushes and seedlings were found as escapes in nearby woodlots and groves. There is no doubt that escaped bushes of the common barberry still exist in many places in the state.

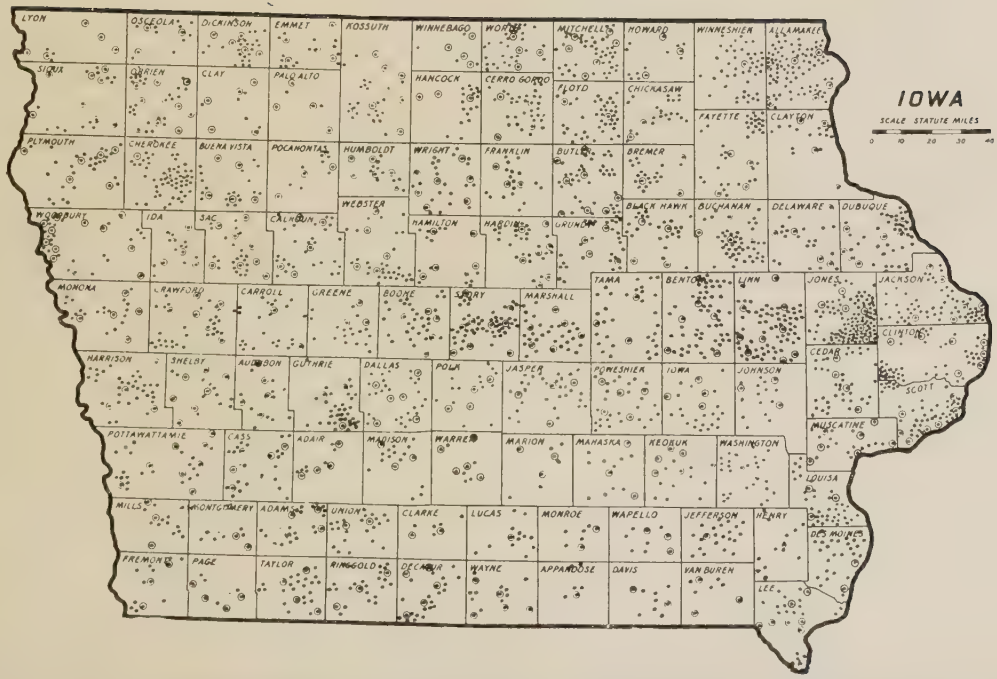

Fig. 8. Each single dot on this map represents a rural property on which common barberries have been found. Each dot within a circle represents a city or town in which barberries have been found. These barberries were found and destroyed from 1918 to 1926.

It will be noted from the state map (fig. 8) that the common barberry has been found widely distributed thruout Iowa. Many of these bushes were found in dense woodlands and in almost inaccessible places. Under such circumstances, it is difficult even for trained men to locate every bush. Seedlings may continue to appear for a number of years from scattered seeds. Hence, it is necessary to survey many counties a second time and some areas may need additional inspection to find and eradicate all the scattered barberry bushes and seedlings.

Destroying the Common Barberry

The common barberry may be destroyed by the use of chemicals or by digging.

Salt: An application of crushed rock salt or ice cream salt has been found effective in killing barberries. More than 155 tons of salt have been used in killing barberries in Iowa since 1923.

> Ten to fifteen pounds of salt is sufficient to kill a bush having a ground line diameter of twelve inches. Large bushes should receive more in proportion. The salt should be piled in and about the base of the plant so as to surround all stalks (cover).

All stems growing a little distance from the main clump must be treated separately. This treatment will render the soil in the immediate vicinity of the bush unfit for plant growth for at least one year. For this reason, salt should not be used if valuable ornamental plants or trees are growing within a few feet or if it is desired to replace the barberry with other shrubbery. If there is any danger of the salt being eaten by livestock or poultry, it should be covered with stones, brush or pieces of boards.

Kerosene: Another chemical sometimes recommended is kerosene. As a killing agent, it acts more slowly than common salt. It is as effective, however, and may be used if immediate killing is not necessary.

> Apply one gallon of kerosene to the crown of a bush with a ground line diameter of about twelve inches. Care should be used not to miss shoots growing a short distance from the main clump.

Digging: In the early years of the campaign and before methods of chemical eradication were developed, barberries were eradicated almost entirely by digging. Because other plants are as readily killed by salt or kerosene, it sometimes is necessary still to eradicate bushes by digging to avoid any damage to nearby valuable shrubbery or trees.

> The barberry bush has a large shallow root system close to the surface of the soil and spreading a considerable distance from the plant. If, when digging, any portions of roots are left in the ground they frequently sprout and produce many new plants. Tractors, trucks and teams are often used in pulling the larger bushes. Small roots always remain when bushes are pulled. Root fragments one-fourth inch in diameter and three inches long will sprout and produce new plants (fig. 9). It should be emphasized that every root fragment must be removed to insure permanent eradication.

Cooperation Necessary

Since 1918, thousands of common barberry bushes have been eradicated in Iowa. Much valuable assistance has been given the barberry eradication campaign in Iowa by many different organizations. Farmers and townspeople of the state have rendered valuable assistance by

Fig. 9. Showing results of improper digging. Note how barberry sprouts grow from root fragments left in the ground.

furnishing time and chemicals for eradicating barberries. The Conference for the Prevention of Grain Rust, an organization composed of business men and farmer organizations of the eradication area, has contributed very materially to this campaign.

In order to finish the task of eradicating the common barberry from Iowa, it is absolutely necessary that its citizens continue their splendid cooperation. The real purpose of the barberry campaign, namely, the protection of the grain crops from ravages of black stem rust, will not be realized without such cooperation.

Leaf Rusts

The small grains of Iowa, as a group, are attacked not only by stem rust, but also by leaf rusts. Tho these latter usually are not so destructive as stem rust, nevertheless they are of much importance. The leaf rusts attack the leaves principally, altho occasionally they are found on the leaf sheaths, stems and glumes. The four leaf rusts known to occur in Iowa are crown rust on oats, leaf rust on wheat, leaf rust on rye and leaf rust on barley. The leaf rust of wheat is frequently confused with stem rust.

CROWN RUST OF OATS

Crown rust *(Puccinia coronata)*, so called because of the crown-like prongs which characterize the winter spores, is a leaf rust. It occurs on oats and a number of grasses, such as marsh fox tail, meadow fescue and oat grass. It does not attack wheat, barley or rye.

Crown rust of oats is widely distributed in Iowa. The summer stage generally appears early in June. Its destructiveness depends upon the earliness with which it appears, its proximity to buckthorns and the weather conditions during May and June. If crown rust is unusually severe in early June, it will often prevent the oats from heading.

Crown rust is distinguished readily from stem rust of oats by its brilliant orange-colored masses of spores usually borne on the leaves. It also differs from stem rust in the fact that its alternate host is the buckthorn instead of the barberry. Its life history in other respects is quite like that of stem rust.

The winter spores on the oat stubble cannot bring about infection of the oat plant except thru the buckthorn. The part played by these bushes in the spread of crown rust, therefore, is important.

Two species of buckthorn found in Iowa are susceptible to crown rust. One of these is the common buckthorn *(Rhamnus cathartica* L.*)* an introduced, ornamental shrub (fig. 10). It attains a height of from five to twenty feet, has glossy, ovate leaves and bears small, inconspicuous, greenish flowers. The berries are spherical, black in color, three to four seeded and very bitter to the taste. Before the introductions of barbed wire, this shrub frequently was used for fences on Iowa farmsteads.

The other buckthorn *(Rhamnus lanceolata* Pursh.*)*, commonly known as lance-leaved buckthorn, grows wild thruout the southern half of the state. It differs from the former by having long, lance-shaped leaves.

Spread of Crown Rust from Buckthorn to Oats

Crown rust has been observed on buckthorn before the summer rust stage appeared on oats, for the past eight years in Iowa, showing that buckthorn is responsible for the initial infection. During the past six years the evidence shows clearly that common buckthorn and lance-leaved buckthorn can start local outbreaks of crown rust on oats. In May of each year, many localities have been noted where the oats were heavily rusted, while oats between these areas were entirely free from rust. Either common or lance-leaved buckthorn was found growing near the center of each of the rusted areas.

During 1921, a detailed study was made of a 120-acre farm at Hinton, Iowa, which was surrounded by a 520-rod hedge of common buckthorn. About one-third of all the surrounding acreage was sown to oats. The buckthorns were heavily rusted by May 17 and the first infection appeared on the oats May 22. By May 29 the rust had spread to oats a mile and a half from the

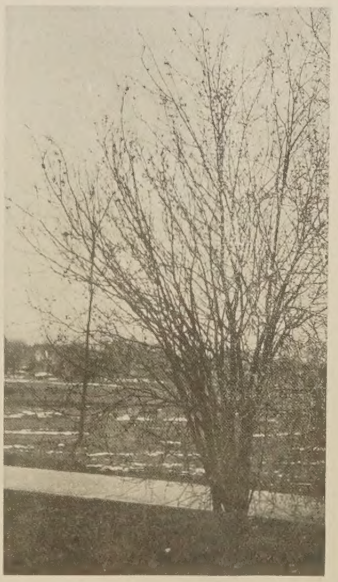

Fig. 10. Common buckthorn (**Rhamnus cathartica**), the shrub that harbors the alternate stage of crown rust of oats.

buckthorns, and by June 10 infection had spread a distance of 53 miles from this hedge. The oats near the hedge were totally destroyed, and the yield of more distant fields was greatly reduced.

Control of Crown Rust

Avoid planting oats in the vicinity of the common or lance-leaved buckthorns or eradicate the buckthorn according to the methods already described for the eradication of the common barberry in the control of stem rust. If buckthorns are planted for ornamental purposes use the species *Rhamnus frangula* and *Rhamnus purshiana*, both of which are hardy and very resistant to crown rust of oats.

Varieties of oats have a wide range of susceptibility, some showing marked resistance to crown rust. Early maturing varieties usually are not severely attacked. Green Russian, a mid-season yellow oat, shows only partial resistance to crown rust. Certain strains of Burt and Red Rust Proof show a marked degree of resistance to this rust. These varieties, however, are not particularly adapted to conditions in the Upper Mississippi Valley. Certain selections from Kherson, such as Iowa 103, Iowar and Iogold often escape crown rust infection because of their early maturity. Iowa 105, another selection from Kherson, is susceptible to crown rust, but resistant to stem rust.

LEAF RUST OF WHEAT

The leaf rust of wheat *(Puccinia triticina)*, as the name implies, confines its attack principally to the leaves of the wheat plant. This rust is present every year and in seasons when weather conditions are favorable it may cause considerable damage. In such seasons, even the glumes and awns of the heads may be infected.

Leaf rust is often quite abundant a month before stem rust is particularly noticeable. If the infection is early, it may become so severe as to prevent heading. The leaves of wheat plants which are infected become covered with numerous small, oval, orange-colored spots. These contain the summer spores.

As the wheat plant matures, the red summer spores are replaced by the brownish-black winter spores. These winter spores do not break thru the epidermis as do those of stem rust. This rust is thought to winter over farther south in the summer spore stage on winter wheat, and is blown into Iowa in the early spring. There is no relation between this rust and the common barberry or buckthorn.

LEAF RUST OF RYE

The leaf rust of rye *(Puccinia dispersa)* is similar to the leaf rust of wheat. It often appears during late April or early May, depending upon the season, and is confined to the leaves, where it appears as reddish spots or pustules resembling those of leaf rust of wheat. There is no relation between this rust and the common barberry. It is known to live over winter in the red or summer spore stage on winter rye.

LEAF RUST OF BARLEY

This rust *(Puccinia simplex)* also is similar to the leaf rust of wheat, but with special preference for barley. In Iowa, this rust generally appears late in the season and causes little injury to barley. There is no relation between this rust and the common barberry or buckthorn.